

Herwig/Pythia Differences in Photon-Jet Balancing

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Highlights:

- Herwig-Pythia Discrepancies Observed in the γ -Jet Balancing When Comparing Data and MC.
- We Present Results from Preliminary Studies Performed both at Calorimeter and at HEPG Level.
- Lower Balancing in Herwig Associated with Softer and Less Resolved Jets.
- Some Indication of Differences in “ K_T -Kick” Modeling (?).
- Lower P_T Tails to be Understood...

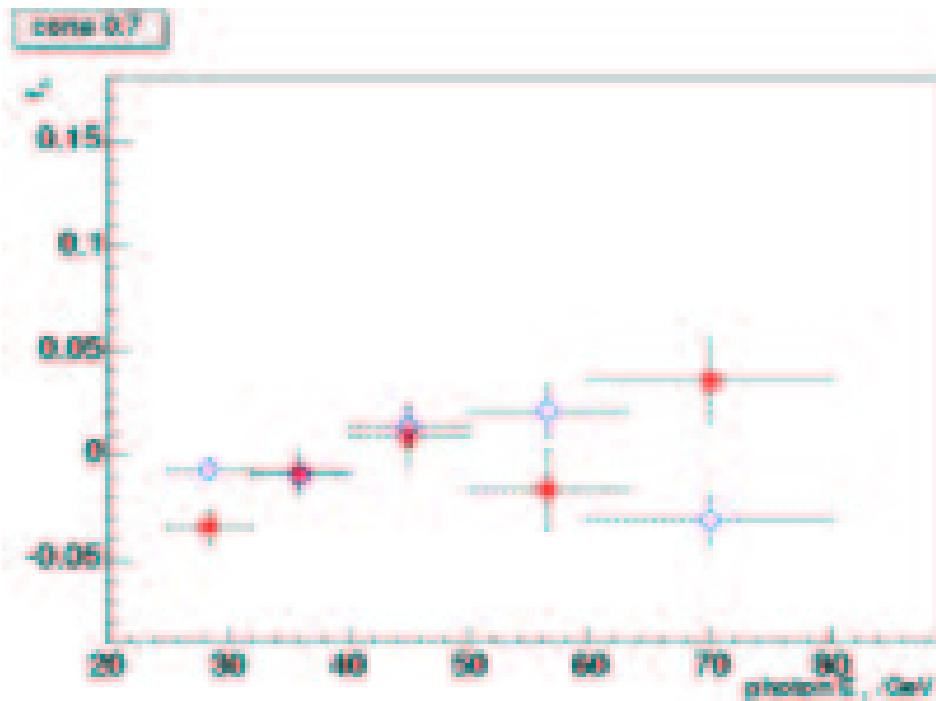
Pythia-Data Comparison in γ -Jet Balancing

(B. Heinemann, A. Gibson)

Central Jets: $0.2 < |\eta^J| < 0.8$, $P_T^{J^2} < 4, 6, 8 \text{ GeV}$ (Cone 0.4, 0.7, 1.0)

$$f_b = (P_T^J - P_T^\gamma) / P_T^\gamma$$

Cone 0.7 “Corrected” Jets:



R_{cone}	Data $< f_b > (\%)$	Pythia MC $< f_b > (\%)$	Data-MC $\Delta (\%)$
0.4	-1.0 ± 0.6	4.0 ± 0.4	-5.0 ± 0.7
0.7	-1.9 ± 0.5	0.5 ± 0.3	-2.4 ± 0.6
1.0	-1.6 ± 0.5	-0.4 ± 0.3	-1.2 ± 0.5

⇒ Up to 5% Difference Depending on Jet Cone.

⇒ Try to Understand Such Difference also Considering Herwig.

Some Technical Informations on Pythia/Herwig Samples..

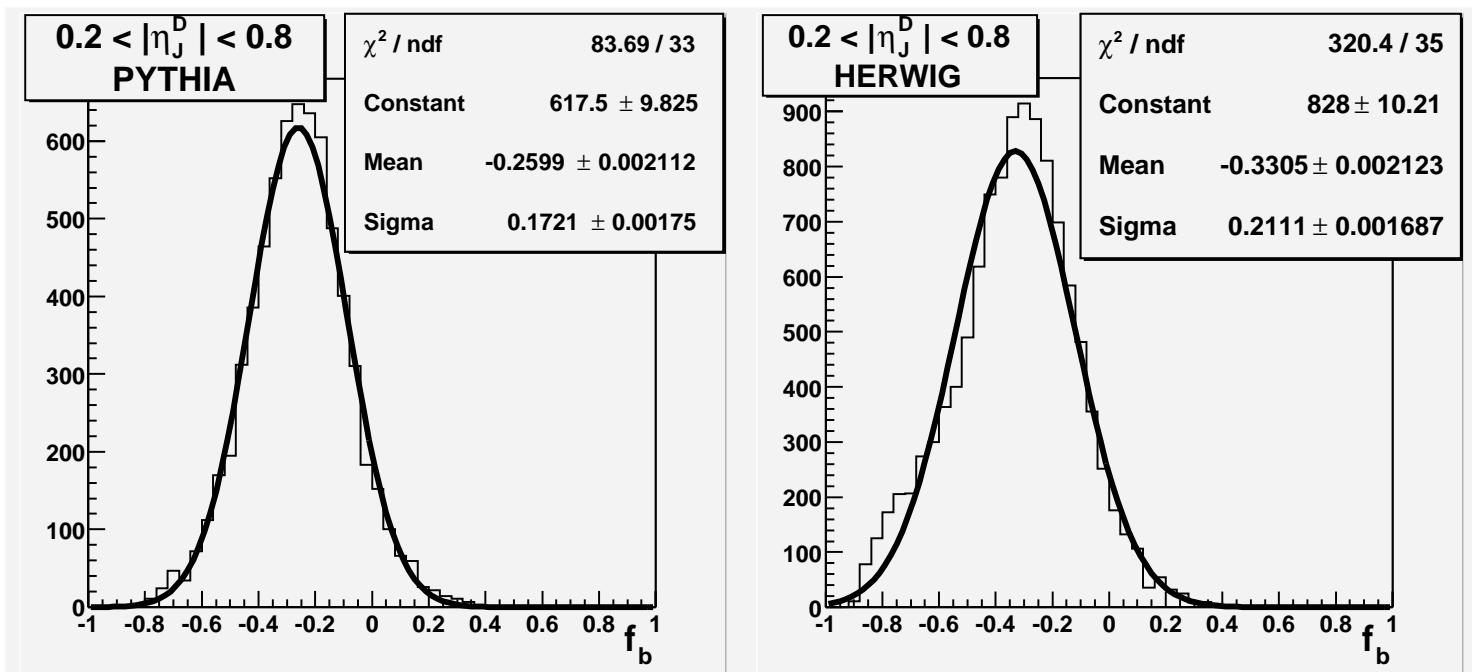
- **Versions:** Herwig-6.500, Pythia-6.216
- **PDFs:** CTEQ5L
- **Process:** $p\bar{p}$ (1960 GeV) ⇒
 - Herwig: $\gamma + \text{jet}$ (Process set 1800)
 - Pythia: single photons ($\text{msub} = 14, 29, 115$)
 - $P_T^{min}(\text{hard}) = 13 \text{ GeV}$
- **HEPG Filter:** $E_T^\gamma > 22 \text{ GeV}$, $|\eta^\gamma| < 1.1$
- **Adronization:**
 - Herwig: “Clpow set 1.26” (default Clpow leads to no B-Baryons)
 - Pythia: default
- **Underlying Event:**
 - Herwig: default
 - Pythia: “Tune A” (R. Field).
- **Full CDF Detector Simulation:** same version.
- **Same Selection Cuts as in Data.**

Pythia-Herwig Comparison in γ -Jet Balancing

(A. Gibson, G.L.)

$$\text{If } \langle P_T^J(\text{Herw}) \rangle = K_J \cdot \langle P_T^J(\text{Pyth}) \rangle \Rightarrow K_J \sim \frac{\langle f_b^{\text{Herw}} \rangle + 1}{\langle f_b^{\text{Pyth}} \rangle + 1}$$

Cone 0.7 “Measured” Jets:



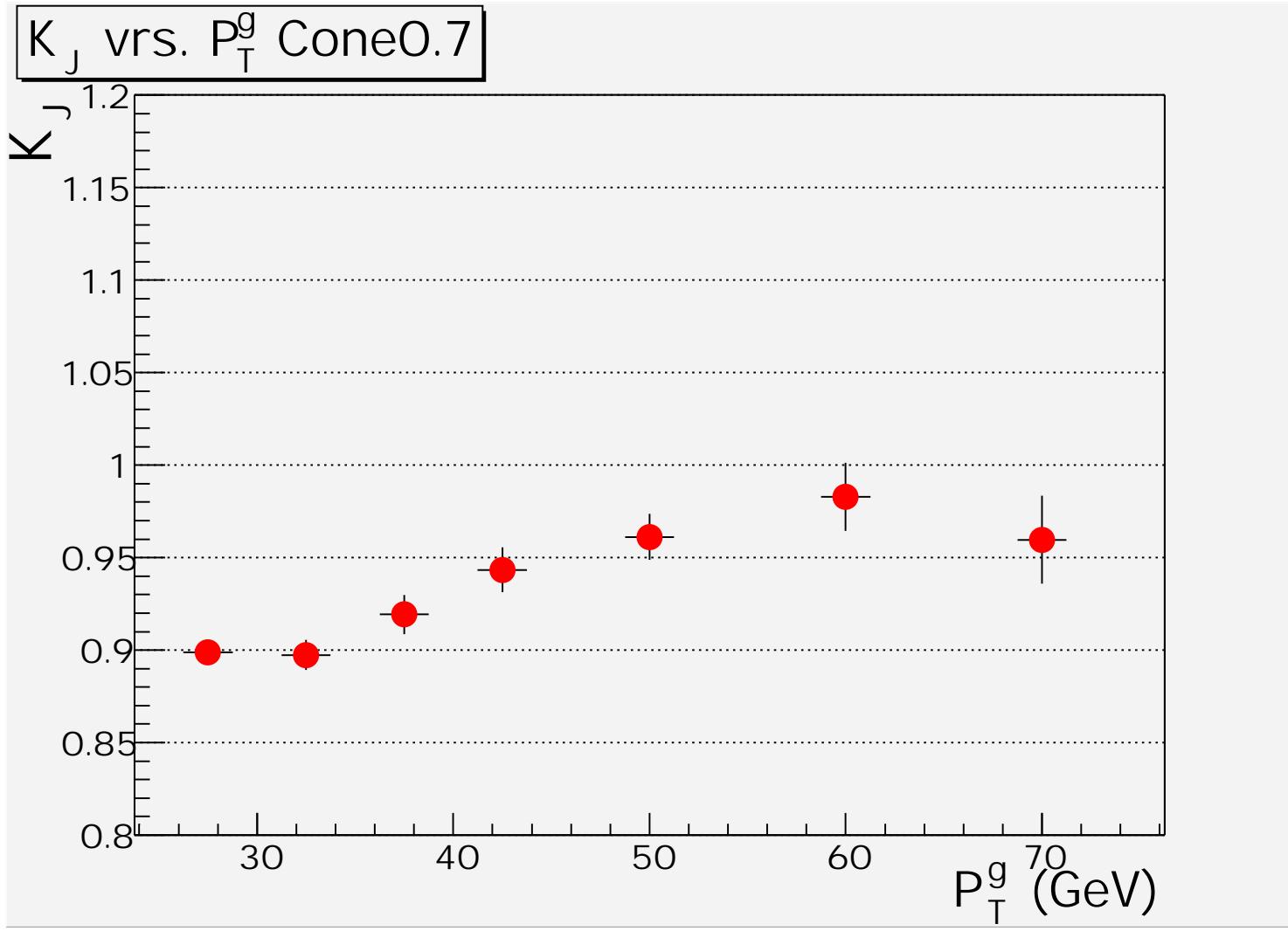
R_{cone}	f_b Pythia $\mu \pm \sigma$	f_b Herwig $\mu \pm \sigma$	Pyth-Herw K_J
0.4	-0.31 ± 0.17	-0.37 ± 0.21	0.907 ± 0.006
0.7	-0.26 ± 0.17	-0.33 ± 0.21	0.905 ± 0.004
1.0	-0.22 ± 0.17	-0.29 ± 0.20	0.915 ± 0.003

$\Rightarrow \sim 9\%$ Difference \sim NOT Depending on Jet Cone.
 $\Rightarrow \sim 30\text{-}25\%$ Difference in Resolution (Herwig Worst) Once Different Mean Values Accounted for.

More on Pythia-Herwig Comparison at Detector Level

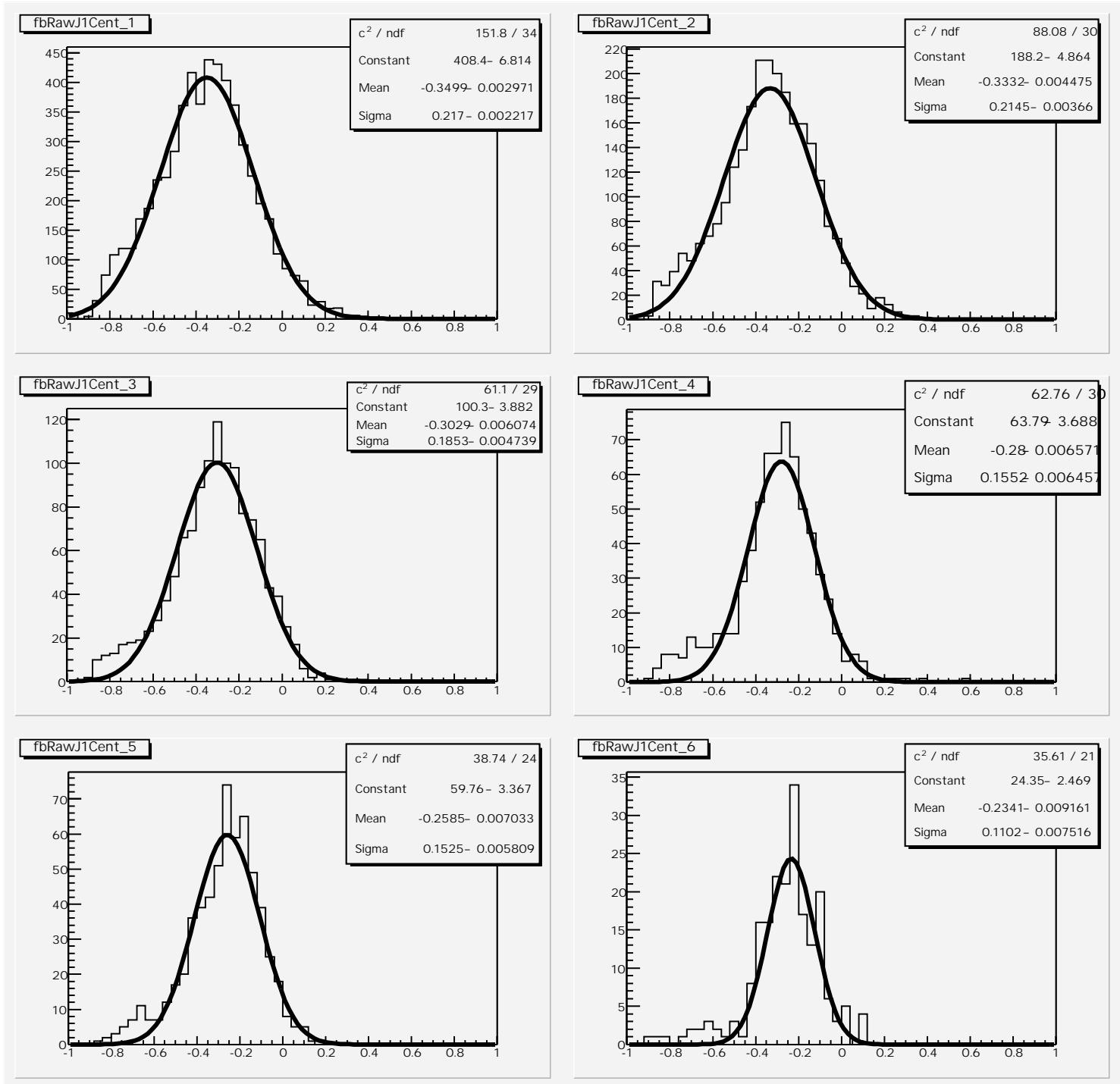
G.L.

Pythia-Herwig K_J vrs. P_T^γ



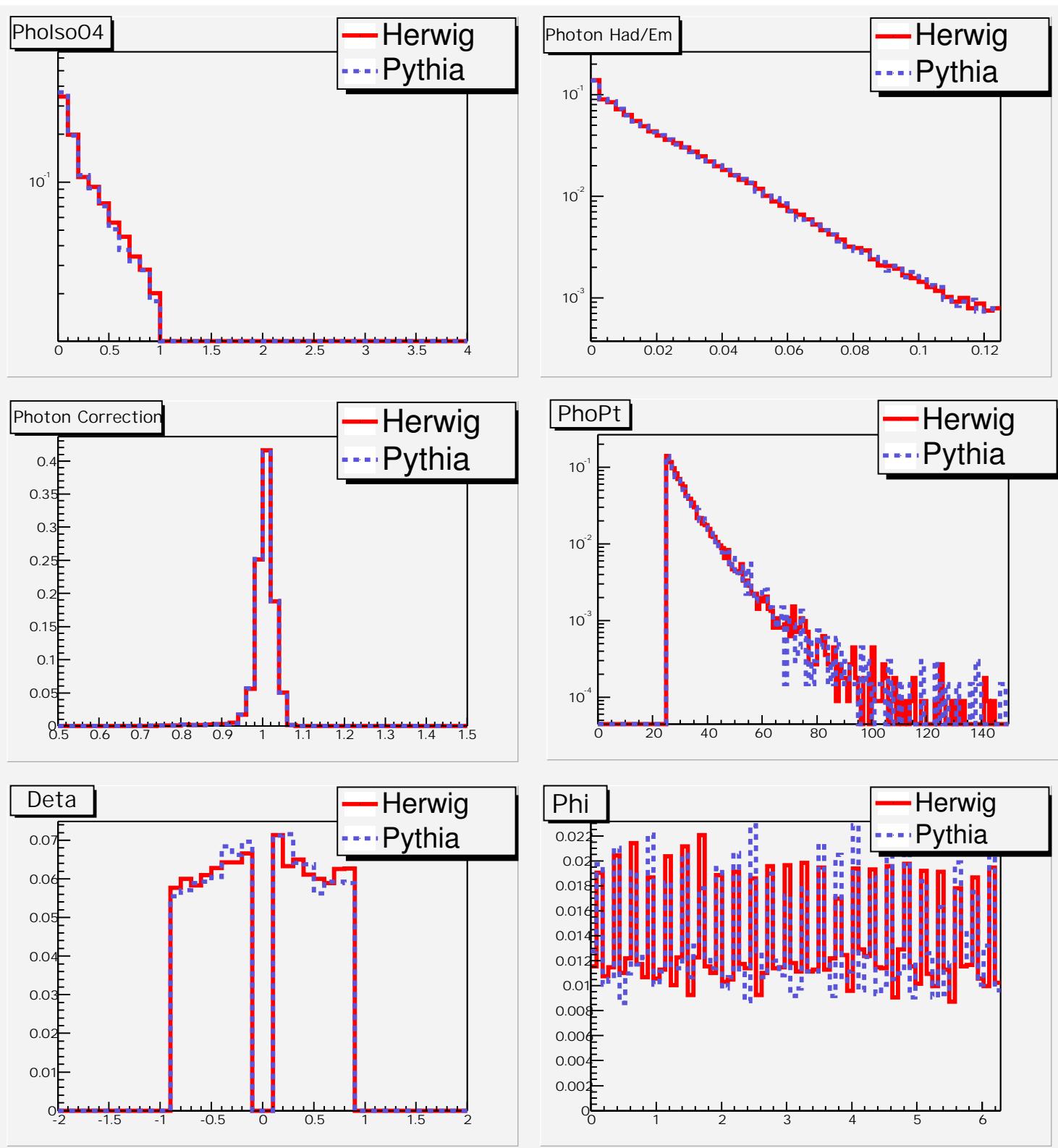
⇒ Same Results With Other Cones.
⇒ Pythia-Herwig Jet Scale Discrepancy Decreasing With P_T :
Indication of Different “ K_T -Kick” Modeling ?

HERWIG: f_b vrs. P_T^γ (25-30, 30-35, ... GeV) (Cone 0.7)



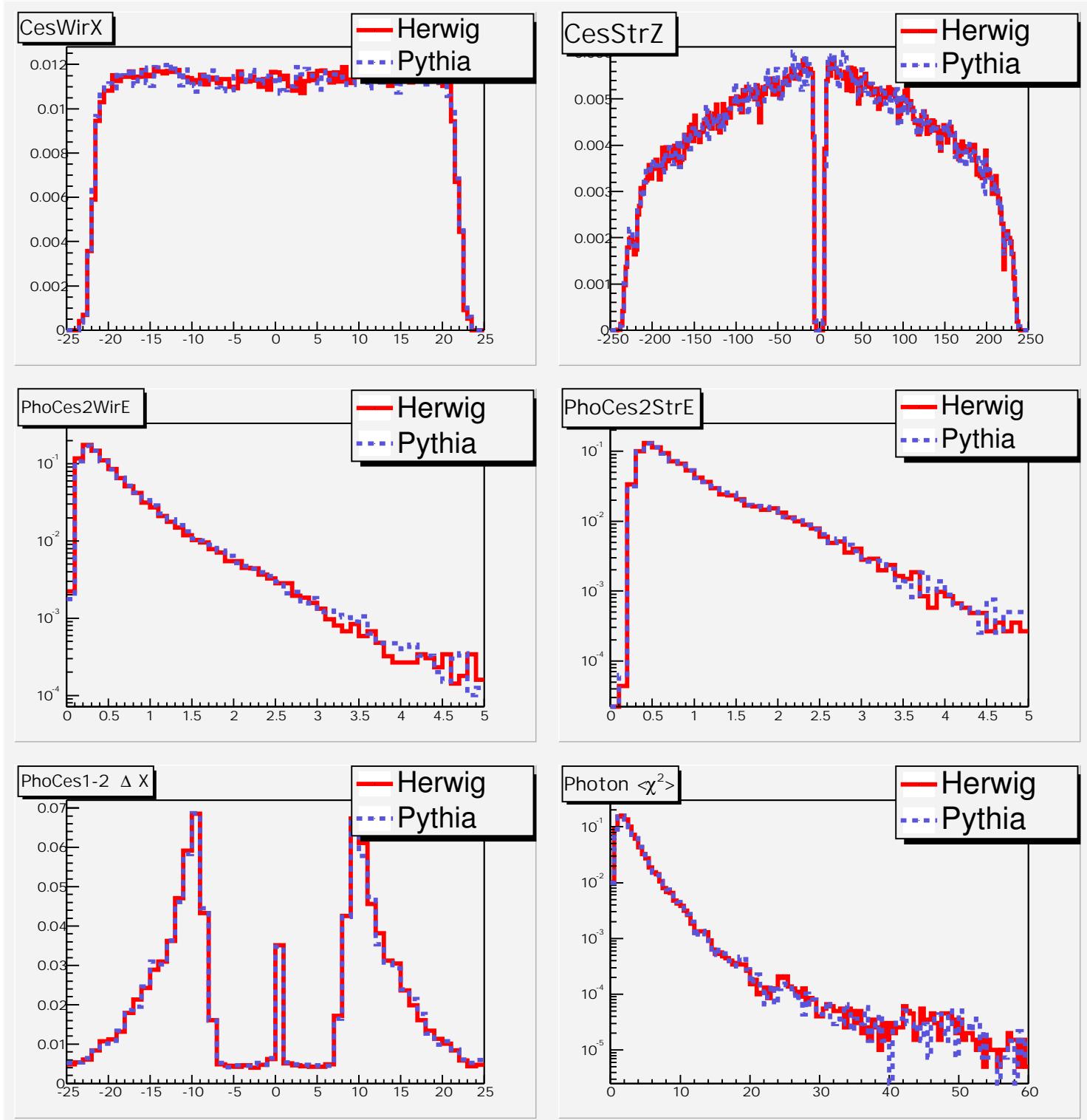
⇒ Residual Tail at Higher P_T (For All Cones).
 ⇒ NOT Observed With Pythia

Pythia-Herwig Comparison I: Photon Selection Variables



⇒ No Substantial Difference...

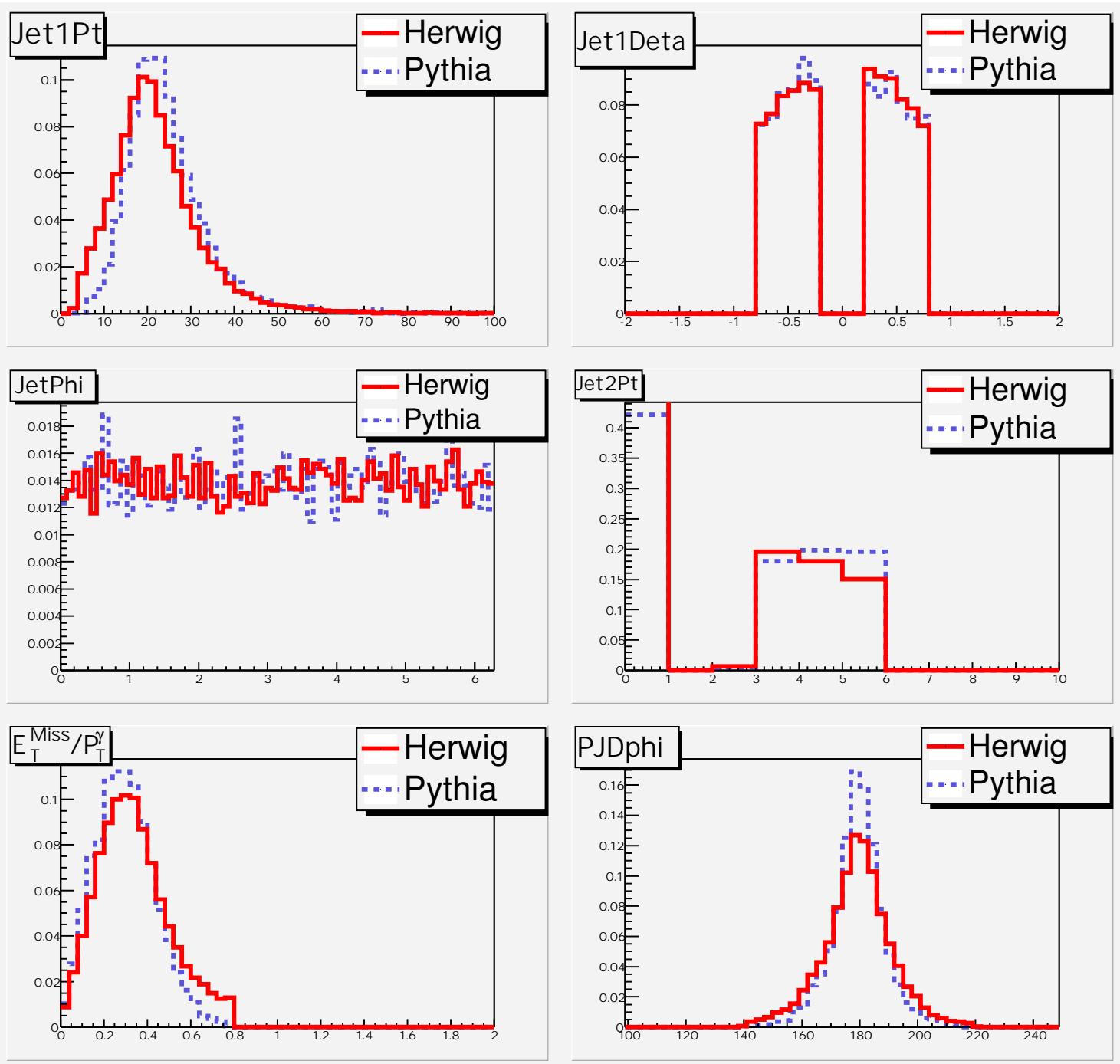
Pythia-Herwig Comparison II: Photon Selection Variables



⇒ No Substantial Difference..

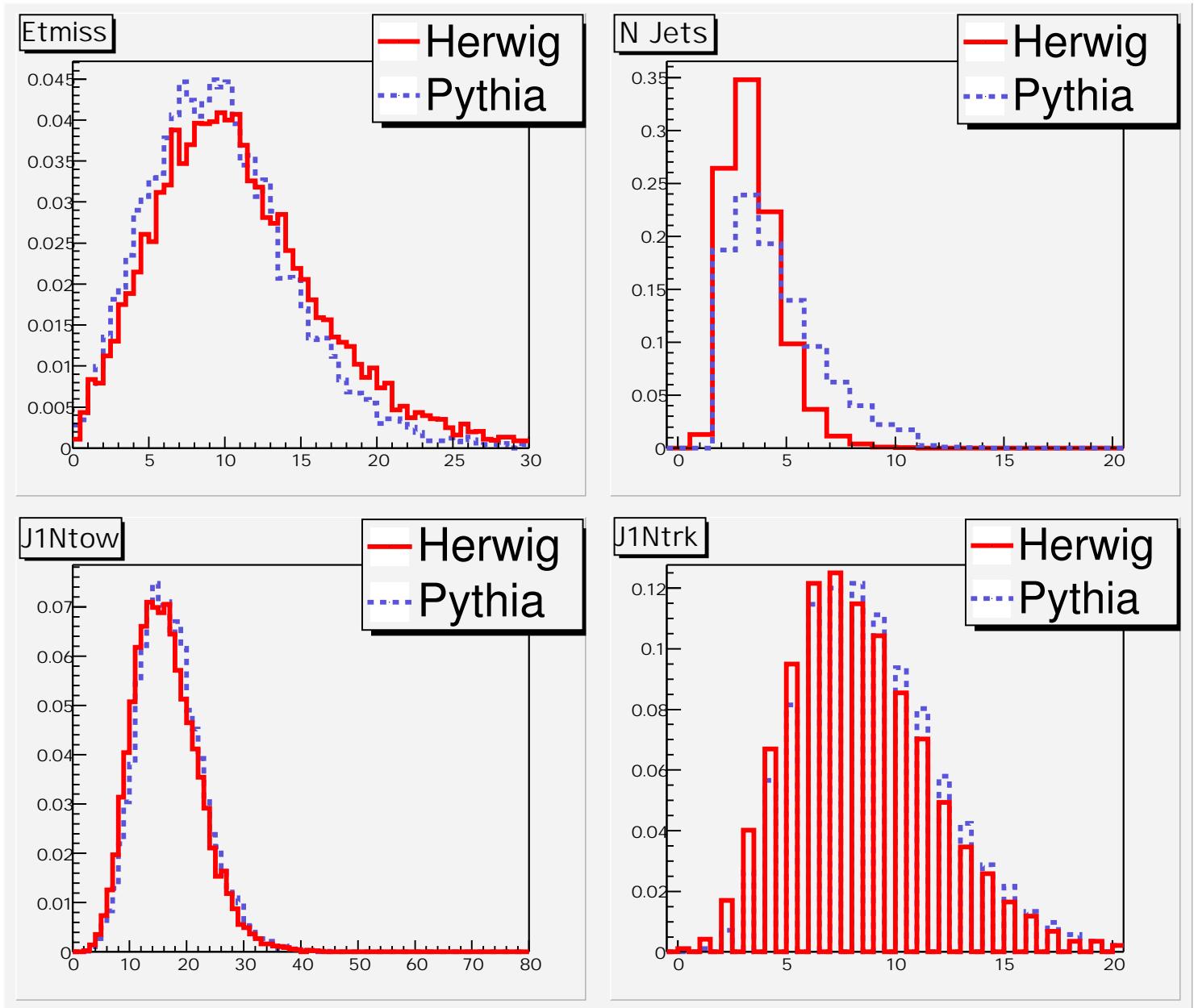
Conclusion: Nothing Strange With the Photon !

Pythia-Herwig Comparison III: Jet/Event Selection Variables



⇒ Herwig Produces “Softer” Jets ...

Pythia-Herwig Comparison IV: Jet/Event Selection Variables

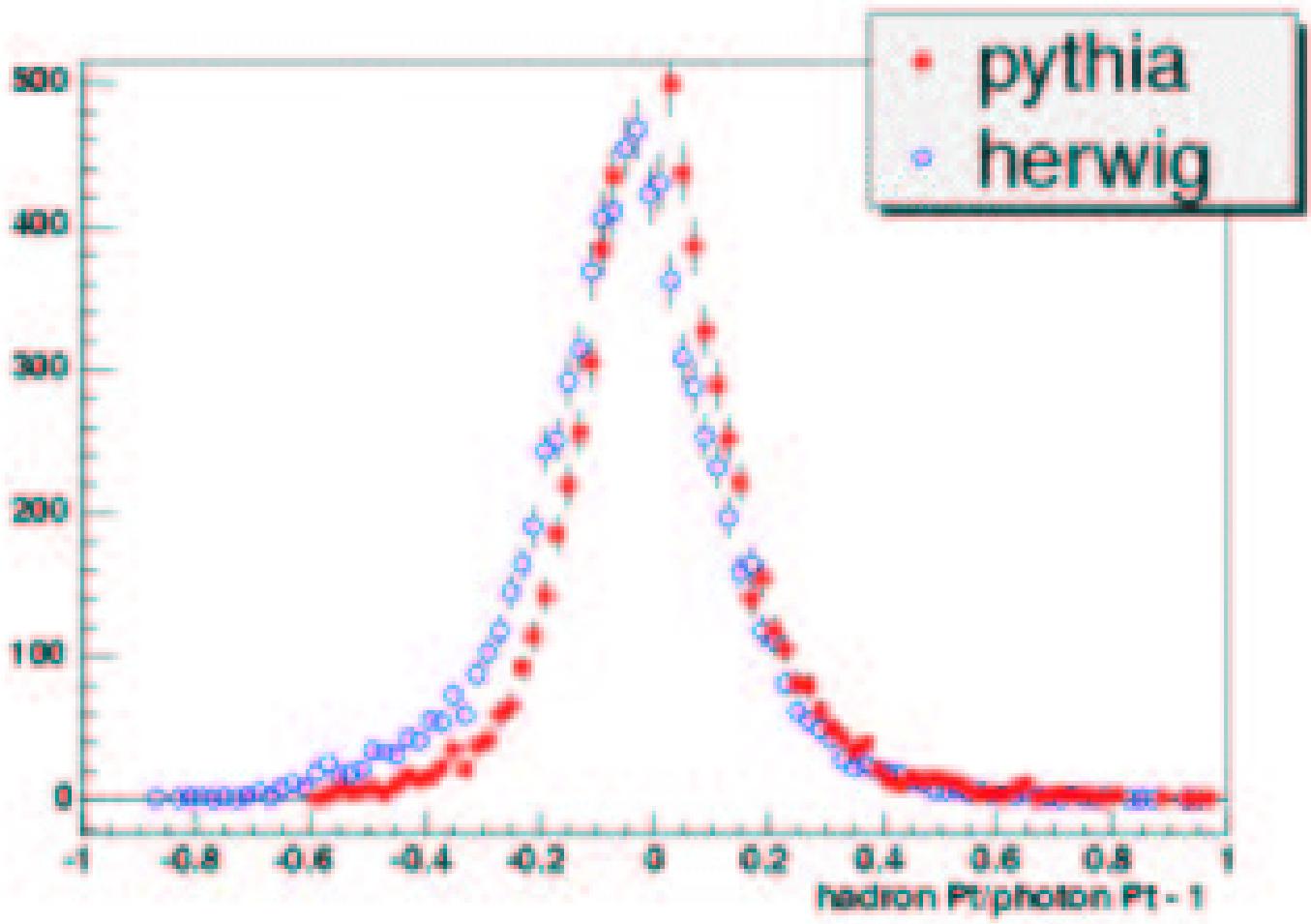


⇒ Major Differences in EtMiss ($\langle \text{Pyth} \rangle = 9.7$, $\langle \text{Herw} \rangle = 10.8$ GeV) and NJet ($\langle \text{Pyth} \rangle = 4.3$, $\langle \text{Herw} \rangle = 3.3$ GeV).
⇒ EtMiss Difference Related to “ K_T -Kick” ?

Pythia-Herwig Comparison at HEPG Level

B. Heinemann

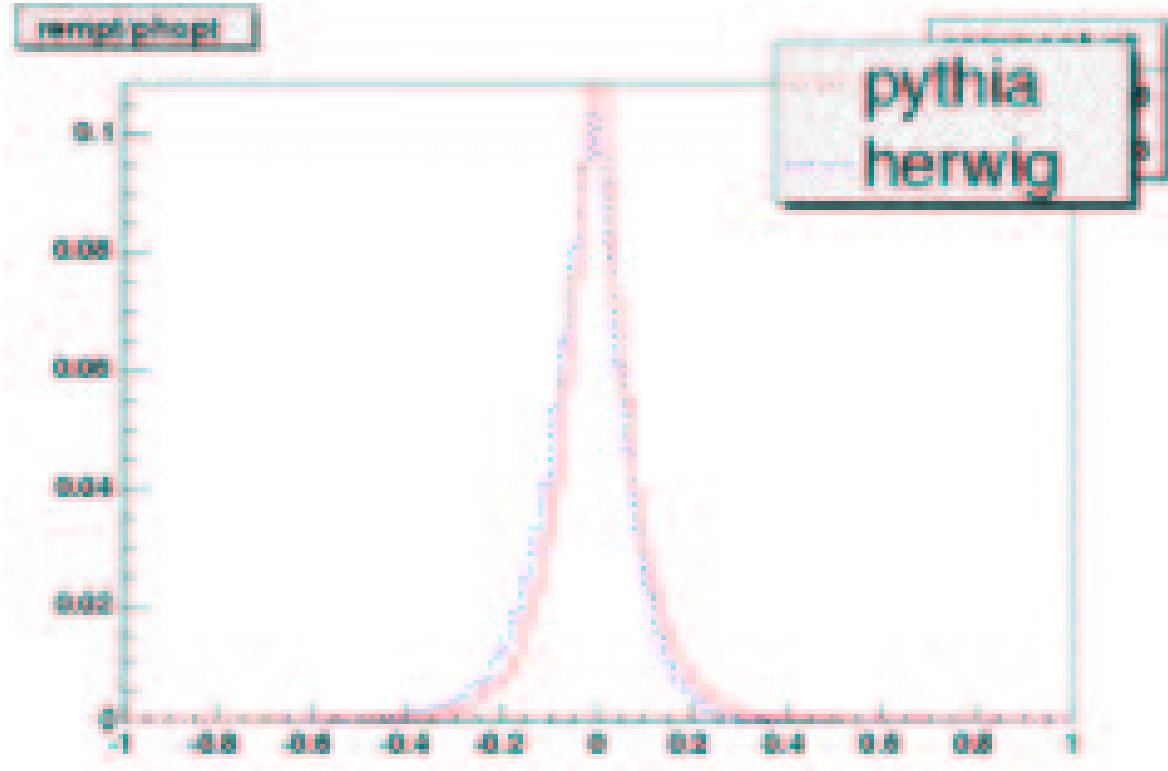
Considering HEPG Particles with $\Delta R < 1$ Around Leading Calorimeter Jet



- $\Rightarrow \mu\text{-Herwig} = -3.8\%, \mu\text{-Pythia} = -0.5\%$
- \Rightarrow This HEPG Level Difference Could be From K_T -Kick, but Here NO K_T in Herwig and “Default” in Pythia.

Considering Hadrons at Higher Eta...

$$P_T(\text{had } |\eta| < 3.5) / P_T^\gamma$$



⇒ Better Agreement (Pythia: 0%, Herwig: -2%) When Considering All Particles Up to $|\eta| < 3.5$.

⇒ Perfect Agreement (Bal. 0%) When Considering All Particles Up to $|\eta| < 10$.

⇒ Herwig Produces More P_T in Forward Region ($|\eta| > 4$). This Can Explain Differences In MissEt (Evaluated up to $|\eta| < 3.6$).

⇒ Are We Accounting K_T -Kick Differences in Such a Way ?

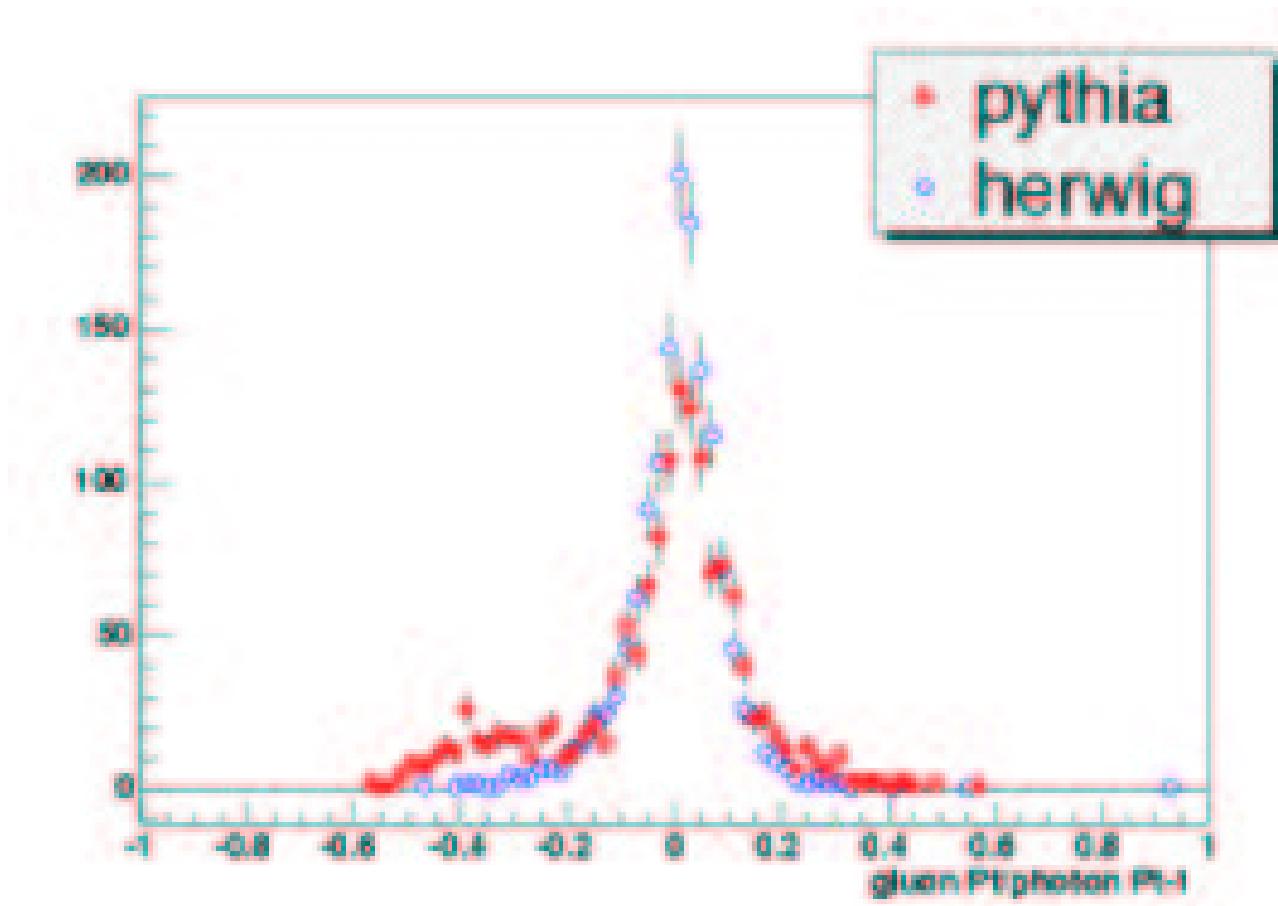
K_T -Kick Studies From Data-MC Comparison in the $Z P_T$ Spectrum

- Default Pythia (as in γ -Jet) Gives Too Little K_T .
- A Tuned Pythia Version Gives Good Description.
- Herwig With $K_t = 1.45$ GeV Too Hard (J. Huston: 1 GeV Can Be a Good Choice..)

Pythia-Herwig Comparison at Parton Level

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Highest P_T Gluon: $P_T(\text{Gluon})/P_T(\text{Photon}) - 1$

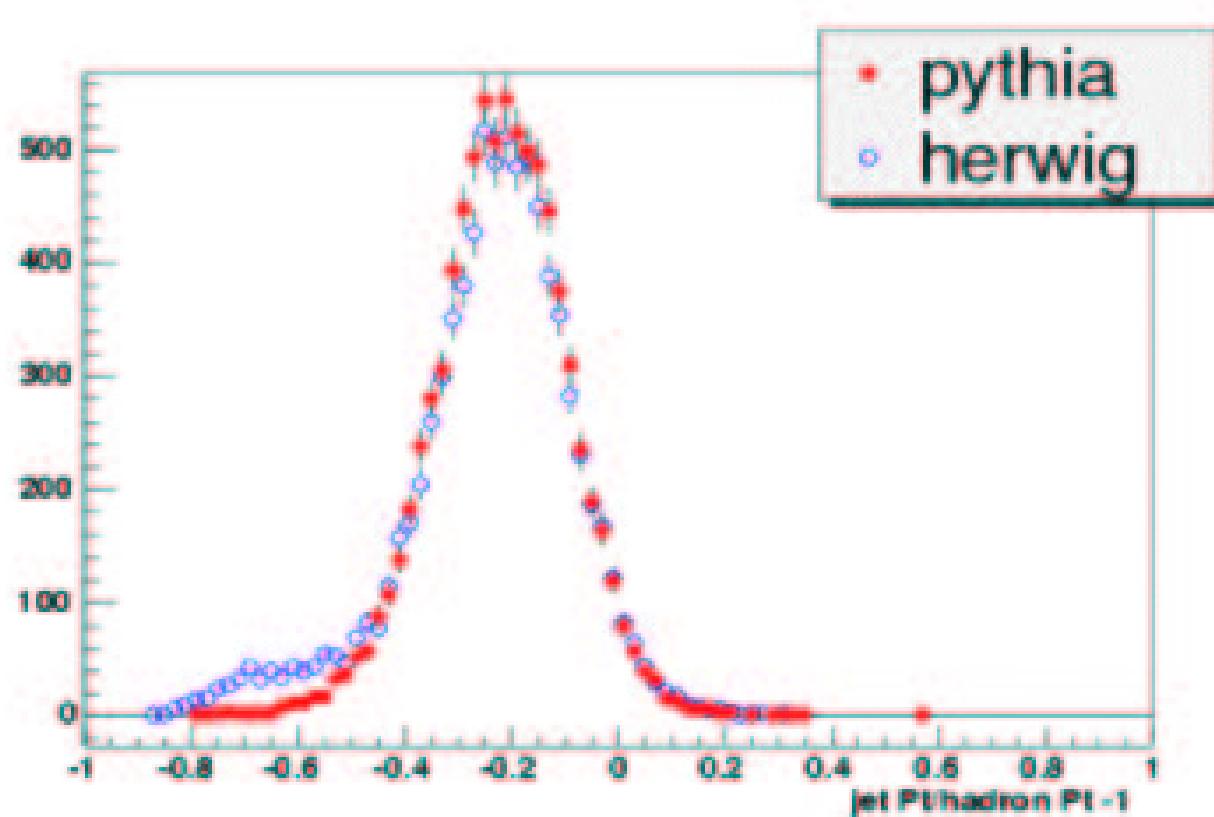


- ⇒ Peaks at the Same Values.
- ⇒ More Tails in Pythia (More Radiation?).
- ⇒ Same Results for Highest P_T Quark.

Cal. Jet Vrs Had. Jet: Pythia-Herwig Comparison

B. Heinemann

$$P_T^J(\text{Cal})/P_T^J(\text{Had}) - 1$$



- ⇒ Means at the Same Values.
- ⇒ Strange Tail in Herwig (Also at OBSP Level).
- ⇒ Effect Coming From Differences In Fragmentation (ex.: Particle P_T Spectrum) ?
- ⇒ Further Investigations Required

Summary & Conclusions

- Disagreement between Pythia and Herwig in the γ -Jet Balance Observed Both at Calorimeter ($\sim 9\%$) and at HEPG ($\sim 3\%$) Level.
- Indications of an Effect Coming From the “Jet Side”.
- No Indication of Differences in U.E. Modeling.
- Indications of a Different K_T -kick Modeling.
- Indications that Herwig Produces More Radiation/Soft Particles (In Particular at Higher η).
- Z P_T Spectrum Well Described by Pythia After Proper Tuning. Herwig Still Need it (is 1 GeV ok ?).
- Agreement in γ -Parton Balance with Some Tails In Pythia (Indicating More Hard Radiation ?).
- Unexpected Tails With Herwig In $P_T^J(\text{Cal})/P_T^J(\text{Had})$ Distribution Which Can Derive From Differences in Fragmentation.
- Are These Differences Observed in Other Pythia/Herwig Generated Processes ?
- More Work is Required in Order to Address Several Pending Issues.